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the course of their development, run through a series of changes of the same order as those which are postulated by the evolution-theory for life in time.

Again, the facts of geographical distribution, as now known, are absolutely incompatible with the hypothesis that existing animals and plants have migrated from a common centre, whether Mount Ararat or any other; and, by demonstrating the similarity of the existing fauna and flora of any locality to that which inhabited the same area in the immediately precedent epoch, have furnished a strong argument in favor of the modifiability of species. Thus, it is not too much to say that the facts of biology known at the present day are all consistent with and in favor of the view of species entertained by Lamarck, while they are unfavorable to, if not incompatible with, those advocated by Cuvier; and that, even if no suggestion has been offered, or could be offered, as to the causes which have led to the gradual evolution of species, the hypothesis that they have arisen by such a process of evolution would be the only one which would have any scientific foundation.

The great service which has been rendered to science by Mr. Darwin, in the "Origin of Species," is that, in the first place, he has marshaled the ascertained facts of biology in such a manner as to render this conclusion irresistible; and, secondly, that he has proved the following proposition: Given, the existence of living matter endowed with variability, the interaction of variation with the conditions of existence must tend to give rise to a differentialism of the living matter into forms having the same morphological relations as are exhibited by the varieties and species which actually exist in Nature.

What is needed for the completion of the theory of the origin of species is, first, definite proof that selective breeding is competent to convert permanent races into physiologically distinct species; and, secondly, the elucidation of the nature of variability. It is conceivable that both the tendency to vary and the directions in which that tendency takes effect are determined by the molecular constitution of a living body, in which case the operation of the changes of external conditions will be indirect, and, so to speak, permissive. It is conceivable, on the other hand, that the tendency to vary is both originated and directed by the influence of external conditions, while it is also conceivable that both variation and the direction which variation takes are partly determined by intrinsic and partly by extrinsic conditions.—*The American Cyclopædia.*

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MALARIA.[1]

BY CHARLES P. RUSSEL, M. D.

THE terms *malaria* and *miasm* in medical phraseology include the causes of a large class of affections—what are known more particularly as *zymotic* diseases, which depend upon a variety of specific organic poisons whose essential nature, composition, and form, are mostly inappreciable as yet by scientific research. The general understanding, however, of these terms, is more limited; and, in conformity with the popular idea, I shall in the present paper confine their application to the cause of those wide-spread disorders, *intermittent* and *remittent* fevers—the former of which is so well known as "chills and fever" or "fever and ague."

"Time out of mind," as Watson remarks, "it had been matter of common observation that the inhabitants of wet and marshy situations were especially subject to these definite and unequivocal forms of disease." The same natural agencies which are now at work elaborating, evolving, and disseminating malaria must have been equally in operation ever since the surface of the earth assumed its present condition. Vast and remote wildernesses that have never known human presence teem, as of yore, with deadly exhalations that almost preclude the bold attempts of enterprising man to lay bare their secrets. There are some parts of India, as Bishop Heber informs us, which even monkeys and other wild animals instinctively desert between April and October of each year. The tigers go up to the hills; the antelopes and wild-hogs make incursions into the cultivated plains; and those persons, such as *dâk-bearers* and military people, who are obliged to venture into the marshy jungles, agree that not so much as a bird can be heard or seen in the frightful solitude.

The celebrated Pontine Marshes may be regarded as the classic home of malaria. The older historical records describe this tract as occupied with numerous towns by the Volsci. It was evidently a fertile region; for we read in Livy that the early Romans sent thither during a season of scarcity for a supply of corn. Three hundred and twelve years B. C., the Censor Appius Claudius Cæcus constructed the Appian Way across the length of the Pontine region, the soil of which must then have been sufficiently compact to support the heavy causeway. At some period of the subsequent century and a half, the country seems to have undergone great deterioration either from natural or civil causes, and to have become partially inundated; for, about 170 B. C., we find the Consul Cornelius Cethegus applying himself to draining the marshes, and restoring the land to cultivation and salu-

[1] A portion of a paper read before the New York Public Health Association, April 13, 1876.

brity. The result of his efforts was, that new and flourishing towns arose on the ruins of the ancient Volscian cities. The civil wars, however, and the devastation which accompanied them, again caused the hydraulic works of the Pontine Marshes to fall into neglect, until they were repaired by Augustus, who constructed several new canals, especially a navigable one skirted by the Appian Way. It was on this canal, at Forum Appii, that Horace embarked one evening, and at the same spot St. Paul first met his countrymen from Rome. Nerva and Trajan both contributed to the drainage of the Pontine Marshes, and left inscriptions, still extant, which testify to their great interest in the project. During the convulsions of the following centuries they were overflowed anew, until in the reign of Theodosius they were once more drained, with most beneficial effect, by a public-spirited individual named Cæcilius Decius. We have no subsequent account of the condition of this region until the end of the thirteenth century, when Pope Boniface VIII. constructed some works to drain it. Leo X. employed the engineer Giovanni Scotti to repair and enlarge the canal of Badino, the principal outlet of the marshes, and Sixtus V. built a large lateral canal. The most important improvements, however, were effected by Pius VI., and a system of effectual drainage was almost completed, when the low condition of the papal treasury and the confusion attendant upon the French Revolutionary invasion completely arrested the undertaking, which up to that time had involved an expense equal to $1,622,000. No new works have since been attempted, although the authorities endeavor to keep the canals clear and the dikes in repair. The greater part of the plain is covered with rich pastures; but, except the post-stations along the highway, and some scattered huts of herdsmen, it has and can have no permanent population.

Taking the United States census of 1870 as a guide for our own country, we find malarial fevers forming a very important feature of the mortality-tables. They are most fatal in Florida, Louisiana, and Texas. Next in order follow Arkansas, Mississippi, Alabama, Georgia, Missouri, Kansas, and Nevada. In another group distinguished by a somewhat less mortality we find New Mexico, the Carolinas, Virginia, Tennessee, Kentucky, Illinois, and Indiana. Those States marked by the lowest mortality are the New England and Middle States, Wisconsin, and Minnesota. In California there is a considerable ratio of mortality, diminishing easterly in Utah, and northerly in Oregon and Washington Territory, while it augments largely toward the south in New Mexico. Since the census was taken, however, that is, since about 1869, there has been noticed an evident extension of the subtile miasmatic agency over regions previously exempt from it, in the Middle and New England States. The increase of mortality by this cause in New York City has been notable, but can scarcely be attributed entirely to local influences. In 1868 there were registered in this city

only 98 deaths from malarial fevers. In 1869 they rose to 128; in 1870, to 213; in 1871, to 291; and in 1872, to 348: an increase of 350 per cent. in four years. Since then some diminution in their fatality has occurred. They occasioned 282 deaths in 1873, 295 in 1874, and 275 in 1875.

Let us now consider under what circumstances malaria may be produced. Although it cannot be denied that there are peculiar localities where, with apparently every presumed condition existing for the development of malaria, that poison is entirely absent, yet the concurrence of malarial emanations with such conditions in innumerable places establishes beyond a question their direct relation. The *essential* element in the production of malaria would appear to be *vegetable decomposition;* and, in order that this process shall ensue, the simultaneous operation of *air*, *moisture*, and *a certain high range of temperature*, is absolutely required. Localities, therefore, where such combination occurs, are prolific of malaria. Of this character are swamps and morasses, alluvial deposits, loose, porous, sandy, and argillaceous soils, or deep, loamy, marly lands underlaid by impermeable strata affording capacity for the retention of moisture, regions exposed to periodical or occasional inundation, places left bare by the subsidence of lakes or drying up of streams, and particularly areas subject to the intermingling of salt and fresh water—as salt-marshes into which fresh streams discharge, or regions liable to tidal overflow and recession.

The exhalations from marshy tracts are recognized by their effects upon the human system throughout the world; and the fact that marshes bear a causative relation to malaria has been demonstrated in numerous instances by the disappearance of fever after thorough drainage and cultivation, and its reappearance upon their being allowed to relapse into neglect. The favorable effect of drainage and cultivation is owing both to the systematic removal of water near the surface, and most probably also to the absorption by the growing crops of the products of organic decomposition. On the same principle Prof. Maury succeeded in antagonizing the noxious emanations from a marsh surrounding the observatory at Washington by planting it thickly with sunflowers, which seem to possess an extraordinary absorbing power. Sebastian is inclined to believe that the *Calamus aromaticus* which grows in some swamps has a similar neutralizing quality. Swamps covered with water are not so dangerous as those partially dry, the layer of water serving as a protection against the access of air and heat to the vegetable matter underneath.

A certain continuous range of temperature seems essential to the development of malaria, which is almost unknown beyond 60° north and 57° south latitude, and during the cold season in the temperate zone. According to Hirsch, it prevails up to various degrees of latitude and average annual temperature. It is the average summer tem-

perature, however, that is of account, and the northern limit of this lies between the isotherms of 59° and 59.8° Fahr., giving a prolonged temperature sufficiently high to insure vegetable decomposition.

The alluvial soil along the banks of rivers and at their deltas, as those of the Ganges, Nile, Orinoco, and Mississippi, gives rise to fevers of a very malignant type. Their banks are subject to overflow, and frequently have a clayey subsoil, presenting an obstacle to percolation—thus upon the river's receding into its ordinary channel its banks remain damp below the surface, and disease is generated by the sun's agency. A like process annually takes place in the extensive plains and table-lands formed of alluvium washed down from mountain-ranges during the lapse of centuries, and having few actual marshes. Profuse rains, succeeded by dry hot seasons, render such regions exceedingly insalubrious during certain periods of the year. Somewhat similar in character are the oases of the Desert of Sahara, which abound in malaria. Hirsch describes these spots as consisting of trough-like depressions in a rocky or highly-hygroscopic soil, the receptacle of subterranean waters, and covered with a layer of alluvium, the surface of the oasis. In this the fierce heat of the sun causes cracks and deep rifts in the earth, which give free vent to the miasm evolved from beneath.

Sandy plains, especially when at the foot of tropical hills and covered with vegetation, as the "Terai" at the base of the Himalayan range, are often infested with malaria. In other cases sandy plains at a distance from hills, apparently dry and not subject to variations in the ground-water, are equally sources of the poison. Such instances as the latter might seem to militate against the generally-accepted theory, but actually do not. Some sands which appear quite free from organic admixture are really the reverse. Faure has pointed out that the sandy soil of the Landes in Southwestern France contains a large amount of organic ingredient which is constantly decomposing and gives rise to periodic fevers. Under such sands, moreover, there is frequently a subsoil of clay. Here, then, assuming a continued high range of temperature, we find all the conditions necessary for the production of malaria.

Localities subject to the intermixture of salt and fresh water are particularly prone to malaria. The Maremmas of Italy afford examples of this on a large scale. The Maremma of Lucca consists of three basins formerly dotted over with ponds and pools. It had been for centuries frequently overflowed by the sea-tides which intermingled with its fresh ponds. Malarial fevers ravaged it and rendered it almost uninhabitable. To the wayfarer who was so imprudent as to spend a night of August or September within its desolate bounds, the penalty was almost certain death. A remedy for this deplorable condition of things was long sought. A proposition had been made in 1714 by the engineer Rondelli to attempt the exclusion of the sea.

Renewed in 1730 by Manfredi, and six years later by Zendrini, a mathematician of Bologna, the idea was finally carried into execution in 1740. The initial attempt was made upon the principal and most unhealthful basin. A sluice was constructed at the entrance of the canal of Burlamacca through which the waters of the sea penetrated into the basin to its central pond. The flood-gate was so arranged as to act like a valve, shutting by the pressure of the rising tide and opening when it fell. The success of this enterprise was so complete that in the following year the miasmatic diseases which had never failed to show themselves annually did not reappear, and the whole district was rendered salubrious. It was at this period that the village of Viarregio, previously abandoned and composed only of a few fishers' huts grouped at the foot of an old tower where galley-slaves were confined, became a place of fashionable resort during the summer for the aristocracy of Lucca. This fact of a region's being rendered healthy by the exclusion of sea-water is curious, but made more decisive still by its counter-proof. In 1768–'69 fevers suddenly sprang up again as bad as ever in the same territory. Upon the cause being investigated, it was found that the sluice had become deranged and the mixture of waters had been reëstablished. Upon the flood-gate being repaired, the malaria was again extinguished. The same occurrence happened in 1784–'85. The sluice having been neglected, there took place in 1784, out of a population of 1,900, the enormous number of 1,200 cases of malarial fever and 92 deaths. In the following year there occurred 103 deaths. The trouble was remedied in the same manner as before. The other portions of the Maremma were rendered healthy later, by sluices successively established at different points. Such a remarkable result necessarily attracted public attention. Leopold II., Grand-duke of Tuscany, was particularly impressed by it, and he conceived the great idea of improving the whole Tuscan Maremma in the same manner. It was an immense undertaking which he contemplated—an actual transformation of a large part of his dominions—and it redounds to his glory that he succeeded, in the face of almost insurmountable obstacles, by the means described, and a properly-directed system of canalization and field-culture, in regenerating a very considerable portion of his territory.

It is not difficult to account for the generation of malaria under such circumstances as those just mentioned. The minute forms of vegetable life with which both fresh and salt water teem require their own special element for continued existence. The intermixture of salt with fresh water introduces a new element with which the life maintained in each separately is incompatible. The surface of the soil consequently after every invasion and retirement of the tide exposes to the action of the heat a mass of defunct vegetable material spread out over an extensive area, and in most favorable condition for speedy decomposition.

Besides the localities enumerated, malaria is apt to be induced or intensified in a region wholly or comparatively exempt from it before, during the disturbance of large extents of soil, as in the construction of canals, roads, railways, fortifications, and dikes, rooting out of timber, preparation of virgin land for cultivation, etc. Vegetable organisms previously hidden and protected underground are thus brought to the surface and exposed to the agencies of putrefaction. Laborers engaged in such works and the neighboring inhabitants soon suffer. The "polders" of Holland, those parts reclaimed from the sea by the erection of dikes, are of this character, and the workmen engaged on them are attacked with malarial troubles of great severity. In this country such instances are common. We have an example at our very doors in the increase of malarial fevers which accompanied the opening of the new boulevards, and the engineering excavations of the Harlem Railroad. After such works have been completed, however, it is not unusual for the vicinity to be restored to healthfulness.

It must be acknowledged that occasionally miasmatic fevers appear and disappear without there having occurred any perceptible changes in the relations of the soil. Such circumstances were reported to the Pennsylvania State Medical Society as having been noticed in 1856 along the Juniata River. Reports to the Connecticut State Medical Society also mention the appearance of miasmatic disorders without any recognized cause in portions of the State previously exempt from them.

There would appear to be some connection between such phenomena and the fluctuating level of the subsoil-water as affected either by rainfalls or subterranean forces. According to Jilek's figures, in Pola, a noted malarious district of Istria, between 1863 and 1868 the number of persons attacked by fever varied from fourteen to fifty-one in every one hundred inhabitants, in exact proportion as the rainfall had varied from one to eighteen inches.

We know that the level of the ground-water is constantly changing. It rises and falls more or less rapidly, and at different rates in different places—in some only a few inches either way annually, but in many places several feet. In Munich, its limit was found by Pettenkofer to be about ten feet. In India, the changes are greater. At Saugor, in Central India, the extremes are between a few inches from the surface during the rains, to seventeen feet in May. At Jubbulpore it varies from two to fifteen feet from the surface. The causes of such changes are rainfalls, pressure of water from seas or rivers, and obstruction of outflow. The pressure of the Rhine has been observed to affect the water in a well 1,670 feet distant from the river. An impeded outflow which raises the level of the ground-water has been productive of an immense spread of paroxysmal fevers. Demster, Taylor, and Ferguson, have reported such to have been the case in

portions of India. The severe and fatal fevers prevailing in Burdowan, Lower Bengal, during the last fifteen or twenty years, have been coincident with obstruction to the natural drainage from mills, and blockage of water-courses. The same cause has doubtless operated to a great extent in producing the fevers of Bloomingdale, Manhattanville, Yorkville, and Harlem. The establishment during the past five years of extensive subsoil drains in those portions of New York has had a visible tendency to diminish the area of malaria. A similar result on a large scale has been noticed in Lincolnshire and other parts of England, where many malarious tracts have been rendered quite healthy by similar measures, having for their object the lowering of the subsoil water-level by an increased outflow.

I have thus far confined my observations to endemic malaria. But, like other diseases dependent upon telluric or organic emanations, miasmatic fevers occasionally assume an epidemic character, and, breaking loose from their native haunts, overspread a wide extent of territory. Thus, as Hertz informs us, nearly the whole of Europe was invaded by such epidemics in 1558—in 1678–'79—from 1718 to 1722—from 1824 to 1827—and from 1845 to 1848. The cause of malaria being thus propagated is as mysterious as that of most epidemics. It is possible that such an epidemic malarial influence has been prevailing here; but we must not lose sight of the fact that sporadic cases of malarial fever appearing in non-malarial districts can frequently be traced to previous exposure in an infected locality.

Malaria, although having its ordinary habitat in low-lying regions, may under conditions favorable for its production exist at great elevations. On the Tuscan Apennines it is found at a height of 1,100 feet above the sea; on the Pyrenees and Mexican Cordilleras, 5,000 feet; on the Himalayas, 6,400 feet; on the island of Ceylon, 6,500 feet; and on the Andes, 11,000 feet. Sometimes, however, at considerable elevations it is unaccountably absent under circumstances apparently supplying every condition for its development. Thus, according to Jourdanet, close to the city of Mexico lies the lake of Tescudo, some twenty-five square miles in extent, composed partly of fresh and partly of brackish water, with a clayey bottom often laid bare over large areas as the result of evaporation under a temperature of 122° to 140° Fahr., notwithstanding which, malarial fevers seldom occur in its vicinity. At Puebla, Mexico, on the other hand, is a very malarious marsh 5,000 feet above the sea. Under ordinary circumstances, a certain altitude affords immunity from malaria, although low elevations of 200 or 300 feet above a miasmatic tract are often more dangerous than the flat lands—the poison seeming to float upward and become intensified. This was long noticeable on the heights of Bergen Hill, West Hoboken, and Weehawken, which overlook the Jersey flats. At present, the elevation

of entire security is not positively determined, but it has been approximated as follows: in Italy, 400 to 500 feet; in California, 1,000 feet; along the Appalachian chain of the United States, 3,000 feet; in the West Indies, 1,400 to 1,800 feet; in India, 2,000 feet. In any of such regions, however, malaria may drift up ravines to an indefinite height. The agency of winds in transporting malaria for considerable distances cannot be questioned. Lancisi, author of the famous work "De Noxiis Paludum Effluviis," published in Rome in 1717, attributes to such influence the fact of the Roman Campagna having become unhealthy after the removal of the sacred groves exposed it to the currents of wind blowing from the Pontine Marshes. In later years, Barat accounts in the same manner for an epidemic of malarial disease which arose in 1869 on the island of Réunion, believing the poison to have been transported by the wind from Mauritius, where such affections were then alarmingly prevalent. In this instance none of the ordinary local causes could account for the outbreak. In four months, over 4,000 cases occurred in a population of 23,000. Salvagnoli and other observers affirm that malarial diseases increase in intensity, and penetrate farther inland on the island of Sicily and in South Italy during the sirocco laden with African miasm.

With regard to the question, "Can drinking-water act as a vehicle for the introduction of malaria into the animal system?" *a priori* it seems reasonable to suppose that such may be the case. If malaria, be it a gaseous substance or an accumulation of minute organisms, cannot pollute water, it differs essentially from other materials of similar form with which we are better acquainted. But, in fact, we have positive proof that malarial fevers may be due to drinking impure water. Mr. Bettington, of the Madras Civil Service, states that in that country it is notorious that the water may produce miasmatic fever and affections of the spleen. He mentions villages placed under similar conditions as to marsh-air, in some of which fevers are prevalent and in others not—the difference resulting from the former drinking marsh-water and the latter pure water. In one village there were two sources of supply—a tank fed by surface and marsh water, and a pure spring; only those who used the tank-water contracted fever. The celebrated instance related by Boudin is still more conclusive on this point. In 1834 there returned to Marseilles from Bona in the ship Argo 120 soldiers, of whom 103 were seized with various forms of malarial fever after drinking marsh-water taken on board at Bona. On the other hand, the sailors of the same vessel, who had pure water, and 780 men embarked on two other vessels, remained well. The few soldiers on the Argo not attacked had purchased their drinking-water from the sailors. Against such positive evidence as this the statement of Finke that in Hungary and Holland marsh-water is drunk without injury is of little value.

Now, a number of careful investigations have been made of the constituents of miasmatic marshes in various parts of the world, with the following results: They contain from thirty to thirty-five per cent. of vegetable organic matter. This consists of humic, ulmic, cremic, and apocremic acids, all substances requiring renewed chemical investigation. Various minute vegetable algoid forms are revealed by microscopic examination—bacteria, vibriones, and microzymes. But all these so-called impurities are found in nearly every running stream and in many harmless well-waters, and to condemn water on account of their presence would be really to reject all waters, even rain, in which minute algoid vesicles (protococci) are often found. Even distilled water may contain bacteria and vibriones. Although, therefore, admitting that water may be contaminated by the presence of malaria, it by no means follows that this poisonous ingredient has any relation to the organic impurities mentioned, or that the latter are in any way injurious, but we should none the less be cautious as to the source of our drinking-water.

The stratum of air overlying typical malarial marshes has also been examined with particular care. It has been found to contain an excess of carbonic acid—watery vapor in large quantity—often carburetted hydrogen, and occasionally free hydrogen, ammonia, and phosphuretted hydrogen. If the marsh contains sulphates, sulphuretted hydrogen is present. Its organic matter blackens sulphuric acid—gives a reddish color to nitrate of silver—has a flocculent appearance, a peculiar odor, and affords evidence of ammonia. The amount in Becchi's analysis was .000118 grain in each cubic foot of air. Ozone had no effect upon it. Besides this organic material, various vegetable and animal matters are arrested when the marsh-air is drawn through water or sulphuric acid—*débris* of plants, infusoria, insects, and even small crustacea. Dr. Balestra has described spores and sporangia of a little algoid plant in the air of the Pontine Marshes. Lemaire and Gratiolet, in 1864, found in the air of one of the most unhealthy marshes of Sologne spherical, ovoid, and fusiform spores and a large number of pale cells, products, no doubt, of vegetable putrefaction. It has been supposed, by Schönbein and others, that ozone is deficient in marsh-air; that the quantity of ozone in the atmosphere and the prevalence of malarial diseases have an inverse proportion; and that ozone, by virtue of its supposed power of destroying organic matters in the air, is an antidote to miasm. There is, however, no evidence at all that ozone and malaria are antagonistic, or bear to each other any relation whatever. These various examinations, though interesting, bring us no nearer to a solution of the question, *What is the nature of malaria?* All of the many substances and forms thus far observed in malarial localities may be found equally in districts perfectly salubrious.

That it gains access to the system principally through the respira-

tory organs is quite certain. What we really do know of it has reference more particularly to its mode of action. It is most dangerous when the sun is down, and it seems almost inert during the day. It appears providential that the same agency which is so potent in its production should be the principal instrument of its destruction. It loves the ground, where in many regions it is so concentrated and deadly as to destroy the incautious sleeper on the earth almost as quickly as the most noxious gas. Hence it is generally regarded as having a specific gravity heavier than that of air, but this is by no means certain. It is doubtless rendered heavy by combining with night-fogs and dews, but upon their being dissipated by the sun it rises into the air and probably becomes innocuous by wide diffusion and dilution. It is intercepted by impediments, such as walls and groves of leafy trees, which obstruct the winds that bear it. Perhaps the latter also neutralize it by absorption. It is likewise neutralized and probably absorbed in passing over a considerable body of water —especially salt-water. The distance necessary to effect this result naturally varies with circumstances—force of winds, concentration, intensity, and abundance of the poison itself. According to Blane, in the channel between Beveland and Walcheren, 3,000 feet of water rendered it inert. In China, three-quarters of a mile, and in the West Indies, one mile, have been required to be effectual.

Recognizing the facts mentioned, the precautions to be observed against malaria are quite obvious. In built-up cities we are protected by pavements and sewers to a great extent, and probably also by the character of the atmosphere, which is artificially warmed by radiation at night, and impregnated with gases which, though injurious in other ways, are antagonistic to malarial emanations. But in malarial suburban and country districts it is otherwise. There certain precautions are necessary. If possible, elevation of a dwelling-place, at least 500 feet above the source of the miasm, is to be recommended in temperate climates, and from 1,500 to 2,000 feet in the tropics. If this be not practicable, thorough subsoil drainage, filling up of low and moist grounds, covering the earth with closely-cut herbage, belts of umbrageous trees interposed between the dwelling and the point of danger, but at a sufficient distance to permit free ventilation, and the access of sunlight; doors and windows opening principally away from the malarial quarter; the house, if possible, to be raised on pillars or arches a few feet above the ground, otherwise a sub-cellar thoroughly cemented—all these are measures of primary importance. The sleeping-apartments should not be below the second story, and should be provided with open fireplaces in which on damp or chilly nights a little fire may be kindled. Exposure to the open air after sunset, or until several hours after sunrise, should be avoided. As whatever tends to lower the vital powers predisposes the individual to malarial invasion, personal hygiene is indispensable. It should of course be

dictated by common-sense, with the object of establishing and maintaining, in the words of the old maxim of the sanitarian, *mens sana in corpore sano.*

ROCK-STRUCTURE.

By Rev. J. MAGENS MELLO, M. A., F. G. S.

THE study of rock-structure is one of great interest to the geologist, and not only does it teach him the various materials of which any particular rock is built up, but it will often lead him to the knowledge of wonderful facts relating to its origin and past history, and will enable him to trace some of the many changes to which it may have been subjected during the lapse of time.

I propose to illustrate this by taking some familiar specimen and showing the ways in which we may investigate its nature and history.

Suppose we take a piece of granite and see what we may learn about it. There are few persons but are acquainted with this rock in some one or more of the forms in which it is found. Our public buildings often present us with splendid illustrations of granite, sometimes roughly hewed, as it has come from the quarry; in other cases highly polished. We have seen the fine gray stones from Aberdeen, or the beautiful red ones from Peterhead and elsewhere. Now, when we begin to examine a piece of one of these granites, we see at once that it is not an homogeneous stone—such, for instance, as is a bit of flint—but that it is built up of various dissimilar-looking materials; and we may notice, moreover, that one or more of those materials is crystalline, that it is shaped in some regular geometrical form. We shall probably be struck with certain whitish or flesh-colored crystals, more conspicuously prominent than the other substances of which the specimen is composed. With some care we may be able to make out in part the form of these crystals, and perhaps to measure one or more of their angles; then, too, we shall notice that these crystals are apparently imbedded in a more glassy-looking substance of a clear and grayish color, and here and there we shall observe some bright spangles of a thin flaky mineral. We shall thus have seen the three principal minerals of which typical granite rock is composed; the larger opaque crystals, whether white or pink, are feldspar, the glassy mineral is quartz, and the little glittering spangles are mica. We may next proceed to a more detailed examination of each of these in turn. We will first ask the chemist what he can tell us of their composition. The chemist is not satisfied with merely knowing that a certain mineral occurring in certain definite crystalline or other forms is quartz, another feldspar, and so on; but he asks further: "What is this quartz? Is it a simple body, or is it, simple as